

**PRELIMINARY SURVEY REPORT:**  
**PRE-INTERVENTION QUANTITATIVE RISK FACTOR ANALYSIS**  
**FOR SHIP RECYCLING AND REPAIR PROCESSES**  
**AT**  
**PUGET SOUND NAVAL SHIPYARD, BREMERTON, WASHINGTON**

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PLANT SURVEYED: Puget Sound Naval Shipyard, 1400 Farragut Avenue, Bremerton, Washington 98314-6001

SIC CODE: 3731

SURVEY DATE: October 20 - 21, 1999

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ANALYTICAL WORK PERFORMED BY: No analytical work required by chemists.

## **DISCLAIMER**

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## **ABSTRACT**

A pre-intervention quantitative risk factor analysis was performed at various shops and locations within Puget Sound Naval Shipyard, a public shipyard that provides ship repair and ship dismantling services for the U.S. Navy. This preliminary analysis is a method to identify and quantify risk factors that workers may be exposed to in the course of their normal work duties. This survey was conducted as part of a larger project, funded through Maritech Advanced Shipbuilding Enterprise and the U.S. Navy, to develop projects to enhance the commercial viability of domestic shipyards. Five specific job tasks were identified for ergonomic analysis. These tasks include: the drydock sorting pad operation, the removal of insulation from vessels, the manual materials handling task in the “cut and carry” process, the use of reciprocating saws to separate components and hulls, and the removal of terrazzo tile with a chipping hammer. The application of exposure assessment techniques provided a quantitative analysis of the risk factors associated with the individual tasks. Possible engineering interventions to address these risk factors for each task are briefly discussed.

## **I. INTRODUCTION**

### **IA. BACKGROUND FOR CONTROL TECHNOLOGY STUDIES**

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposures to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of the completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

### **IB. BACKGROUND FOR THIS STUDY**

The domestic ship building, ship repair, and ship recycling industries have historically had much higher injury/illness incidence rates than those of general industry, manufacturing, or construction. For 1997, the last year available, the Bureau of Labor Statistics reported that shipbuilding and repair (SIC 731) had a recordable injury/illness incidence rate of 21.4 per 100 full-time employees (FTE). By contrast, the manufacturing sector reported a rate of 10.3 per 100 FTE, construction reported a rate of 9.5 per 100 FTE, and all industries reported a rate of 7.1 injuries/illnesses per 100 FTE. When considering only lost workday cases, shipbuilding and repair had an incidence rate of 10.7 per 100 FTE, compared to manufacturing at 4.8, construction at 4.4, and all industries at 3.3 lost workday injuries/illnesses per 100 FTE.

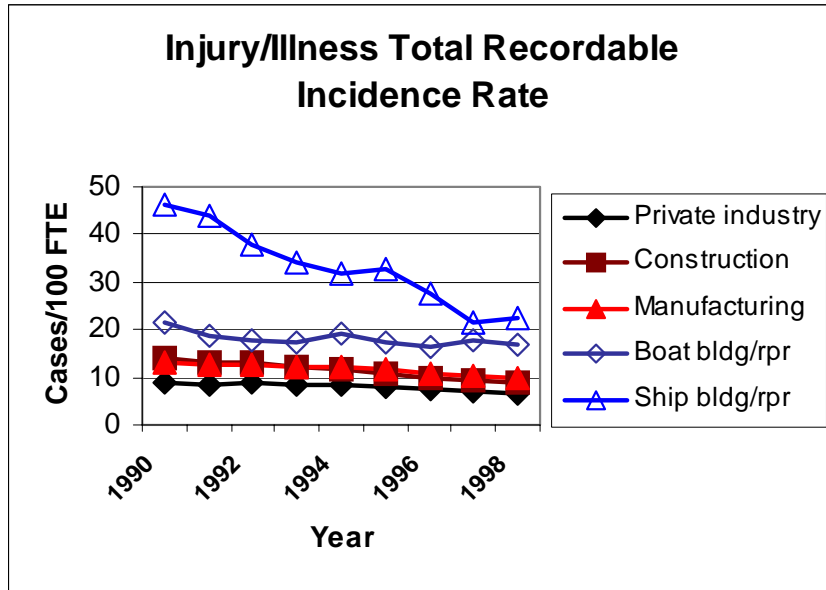


Figure 1. Injury/Illness Total Recordable Incidence Rate, 1990-1998

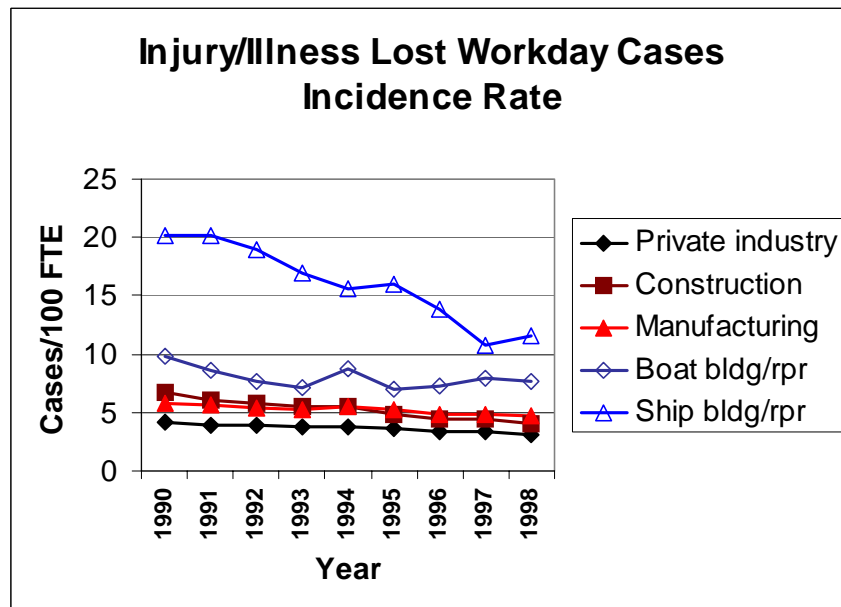


Figure 2. Injury/Illness Lost Workday Cases Incidence Rate, 1990-1998

When comparing shipbuilding to the manufacturing sector for injuries to specific parts of the body, shipbuilding is higher in at least three instances. For upper extremity injuries and illnesses, for the year 1996, shipbuilding reported 110.1 cases per 10,000 FTE while manufacturing reported 76.8 cases. For back injuries for the same year, shipbuilding reported 138 cases per 10,000 FTE while manufacturing reported 56.8 cases. For the lower extremity, shipbuilding reported 136.6 cases per 10,000 FTE to manufacturing's 44.7 cases.

For the entire Puget Sound Naval Shipyard, for the five-year period 1994 to 1998, there were 10,259 injuries and illnesses recorded onto the OSHA 200 Logs for an average annual incidence rate of 22.8 per 100 FTE. In 1997, the PSNS incidence rate was 23.9 compared to a rate of 21.4 for the shipbuilding industry, 12 % higher than the industry average. In 1998, the PSNS incidence rate was 20.1 compared to a shipbuilding industry rate of 22.4, 10 % below the industry average. Similar declines for the incidence rates for days away from work cases and restricted or light duty cases also occurred recently at the shipyard.

When considering only the production workers at PSNS, for the period 1994-1998, there were 8,029 injuries and illnesses recorded for an annual incidence rate of 41.5 per 100 FTE. From 1994 to 1998 there was a decline in both the total incidence rate (22 %) and in the days away from work incidence rate (32 %). When focusing solely on musculoskeletal disorders (MSD) among production workers, MSD represented 54 % of the total number of cases and 67 % of the days away from work cases. Occupations with the highest incidence rates and numbers of MSD include pipefitter, welder, marine mechanic, shipfitter and electrician.

Beginning in 1995 the National Shipbuilding Research Program began funding a project looking at the implementation of ergonomic interventions at a domestic shipyard as a way to reduce Workers' Compensation costs and to improve productivity for targeted processes. That project came to the attention of the Maritime Advisory Committee for Occupational Safety and Health (MACOSH), a standing advisory committee to the Occupational Safety and Health Administration (OSHA). The National Institute for Occupational Safety and Health (NIOSH) began an internally funded project in 1997 looking at ergonomic interventions in new ship construction facilities. In 1998, the U.S. Navy decided to fund a number of research projects looking to improve the commercial viability of domestic shipyards, including projects developing ergonomic interventions for various shipyard tasks or processes. Project personnel within NIOSH successfully competed in the project selection process. The Institute currently receives external project funding from the U.S. Navy through an organization called Maritech Advanced Shipbuilding Enterprise, a consortium of major domestic shipyards.

Shipyards participating in this project will receive an analysis of their injury/illness data, will have at least one ergonomic intervention implemented at their facility, and will have access to a website documenting ergonomic solutions found throughout the domestic maritime industries. The implementation of ergonomic interventions in other industries has resulted in decreases in Workers' Compensation costs, and increases in productivity.

Researchers will identify seven participating shipyards and analyze individual shipyard recordable injury/illness databases by the end of November 1999. Ergonomic interventions will be implemented in each of the shipyards by the end of June 2000. Intervention follow-up analysis will be completed by the end of December 2000. A series of meetings and a workshop to document the ergonomic intervention program will be held by the end of March 2001.

## **IC. BACKGROUND FOR THIS SURVEY**

The Puget Sound Naval Shipyard (PSNS) was selected for a number of reasons. It was decided that the project should look at a variety of yards based on product, processes and location. Puget Sound Naval Shipyard is a public shipyard (i.e., run by the U.S. Navy) in the Pacific Northwest, that performs both ship repair and ship recycling on large military vessels. The shipyard has both a developing ergonomics program and a process improvement program that has addressed ergonomic concerns within the yard. Cooperation by yard personnel to date has been exemplary.

In a letter dated February 24<sup>th</sup>, 1999, PSNS provided a list of problem areas where it was felt NIOSH research efforts should be concentrated. These areas were: 1) hand, arm, and shoulder injuries from using powered hand tools during the “cut and carry” process of ship recycling, 2) back, shoulder, and neck injuries from installing shore electrical power to ships, and the subsequent cable removal and storage, 3) back injuries from installing and removing floor tiles on ships, 4) back, shoulder, and hand injuries from using cutting torches during ship recycling, and 5) back and shoulder injuries from installing and removing staging.

## **II PLANT AND PROCESS DESCRIPTION**

### **IIA. INTRODUCTION**

Plant Description: Puget Sound Naval Shipyard is located adjacent to the city of Bremerton, Washington, one hour west of Seattle by ferry, and approximately 30 miles north of Tacoma. The shipyard proper encompasses 344 acres of land, with additional non-adjointing property totalling 1,558 acres. The shipyard facilities include approximately 400 separate buildings, nine permanent piers including 12,310 feet of deep water space, and six drydocks. This shipyard is the Pacific Northwest’s largest Naval Shore Activity, and one of the largest industrial installations in the State of Washington.

Corporate Ties: U.S. Navy Sea Systems Command

Products: Puget Sound Naval Shipyard performs overhauls and repairs of all sizes and types of U.S. Navy ships as well as being home port for six active ships. Approximately 41 % of the workload of the shipyard involves the inactivation, reactor compartment disposal, and recycling (IRR) of nuclear-powered submarines and surface vessels. Approximately 12 surface vessels and 88 submarines have been recycled in the past 12 years.

Age of Plant: Puget Sound Naval Shipyard was established in 1891 as a U.S. Naval Station. A number of small buildings from that era still survive on site.

Number of Employees, etc: Approximately 8,200 civilian employees, of which 3,500 are production workers. Average age of production workers is approximately 42 years of age.

## **IIB. PROCESS DESCRIPTION**

### **IIB1. Inactivation, Reactor Compartment Disposal, and Recycling (IRR)**

The primary portion of the work being performed at PSNS is in the IRR activity. This area includes the decommissioning of the vessel, the inactivation and removal of pertinent and viable systems, the isolation of the nuclear reactor compartment and the dismantling or recycling of the contents and structure of the vessel. Primary means of dismantling the vessel include either torch cutting or cutting with an electrically-powered reciprocating saw. The dismantling process ranges from 8-10 months for each submarine.

When PSNS was visited in October 1999, IRR activity was taking place in 2 drydocks. One drydock contained the hull of a nuclear-powered cruiser and another drydock contained four nuclear-powered submarines. Vessels are brought to PSNS under their own power and are moored at the docks. While at the docks, initial IRR work is done, dismantling non-essential systems and storing components and scrap for future removal. When drydock space becomes available, the drydocks are flooded and vessels are floated into place onto supports.

### **IIB2. Overhaul/Repair**

Overhaul and repair tasks at PSNS depend upon the needs of the U.S. Navy. Six vessels use PSNS as home port and would have most repairs or overhauls performed at this shipyard. This type of work may involve extensive removal of old systems and replacement with new systems or it may be limited in scope. Various trades would be working on any given repair task within their trade if the work was needed.

### **IIB3. Production**

New production at PSNS is limited primarily to the creation of vessel-specific reactor containment compartments which allow safe handling of the vessel's nuclear reactor compartment during transportation from the yard to final disposal at a federal Department of Energy facility in Hanford, Washington. Metal working processes, including shaping, welding, cutting, and burning of steel, are the primary work tasks. Specific tasks can result in awkward postures, static loads, and manual material handling of supplies or tools.

## **IIC. POTENTIAL HAZARDS**

Major Hazards: Awkward postures, manual material handling, segmental vibration, asbestos, radiation, PCB's.

## **III. METHODOLOGY**

A variety of exposure assessment techniques were implemented where deemed appropriate to the job task being analyzed. The techniques used for analysis include: 1) the Rapid Upper Limb Assessment (RULA); 2) the Strain Index; 3) a University of Michigan Checklist for Upper Extremity Cumulative Trauma Disorders; 4) the OVAKO Work Analysis System (OWAS); 5) a Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling; 6) the NIOSH Lifting Equation; 7) the University of Michigan 3D Static Strength Prediction Model; and 8) the PLIBEL method.

The Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993) is a survey method developed to assess the exposure of workers to risk factors associated with work-related upper limb disorders. On using RULA, the investigator identifies the posture of the upper and lower arm, neck, trunk and legs. Considering muscle use and the force or load involved, the investigator identifies intermediate scores which are cross-tabulated to determine the final RULA score. This final score identifies the level of action recommended to address the job task under consideration.

The Strain Index (Moore and Garg, 1995) provides a semiquantitative job analysis methodology that appears to accurately identify jobs associated with distal upper extremity disorders versus other jobs. The Strain Index is based on ratings of: intensity of exertion, duration of exertion, efforts per minute, hand and wrist posture, speed of work, and duration per day. Each of these ratings is translated into a multiplier. These multipliers are combined to create a single Strain Index score.

The University of Michigan Checklist for Upper Extremity Cumulative Trauma Disorders (Lifshitz and Armstrong, 1986) allows the investigator to survey a job task with regard to the physical stress and the forces involved, the upper limb posture, the suitability of the workstation and tools used, and the repetitiveness of a job task. Negative answers are indicative of conditions that are associated with the development of cumulative trauma disorders.

The OVAKO Work Analysis System (OWAS) (Louhevaara and Suurnäkki, 1992) was developed to assess the quality of postures taken in relation to manual materials handling tasks. Workers are observed repeatedly over the course of the day and postures and forces involved are documented. Work postures and forces involved are cross-tabulated to determine an action category which recommends if, or when, corrective measures should be taken.

The NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling (Waters and Putz-Anderson, 1996) is an example of a simple checklist that can be used as a screening tool to provide a quick determination as to whether or not a particular job task is comprised of conditions that place the worker at risk of developing low back pain.

The NIOSH Lifting Equation (Waters et al, 1993) provides an empirical method to compute the recommended weight limit for manual lifting tasks. The revised equation provides methods for evaluating asymmetrical lifting tasks and less than optimal hand to object coupling. The equation allows the evaluation of a greater range of work durations and lifting frequencies. The equation also accommodates the analysis of multiple lifting tasks. The Lifting Index, the ratio of load lifted to the recommended weight limit, provides a simple means to compare different lifting tasks.

The University of Michigan 3D Static Strength Prediction Program (University of Michigan, 1997) is a useful job design and evaluation tool for the analysis of slow movements used in heavy materials handling tasks. Such tasks can best be analyzed by describing the activity as a sequence of static postures. The program provides graphical representation of the worker postures and the materials handling task. Program output includes the estimated compression on the L5/S1 vertebral disc and the percentage of population capable of the task with respect to limits at the elbow, shoulder, torso, hip, knee and ankle.

The PLIBEL method (Kemmlert, 1995) is a checklist method that links questions concerning awkward work postures, work movements, design of tools and the workplace to specific body regions. In addition, any stressful environmental or organizational conditions should be noted. In general, the PLIBEL method was designed as a standardized and practical assessment tool for the evaluation of ergonomic conditions in the workplace.

Five specific job tasks were identified for further analysis. These processes were: 1) bin emptying at a drydock sorting pad, 2) onboard insulation removal, 3) manual materials handling in “cut and carry” operations, 4) the use of reciprocating saws to separate and reduce the size of components and hull sections, and 5) the removal of terrazzo tile from the decking with a chipping hammer. Each of these processes are examined in greater detail below.

### **IIIA. Bin Emptying on Drydock Sorting Pad**



Figure 3. Emptying Scrap Bin at Drydock Sorting Pad

#### **IIIA1. Bin Emptying at Drydock Sorting Pad Process**

As the surface vessels and submarines are being dismantled as part of the Inactivation, Reactor Compartment Disposal, and Recycling activity, hundreds of bins of scrap metal are generated. Each bin measures approximately 5 feet by 3 feet by 3 feet. The bins hold a variety of material: stainless steel, painted steel, unpainted steel, aluminum, and other metal components. Each bin is filled during the “cut and carry” dismantling process for the vessel or vessels within the drydock. At the time of the site visit, four submarines were being dismantled within the same drydock. The scrap bins are moved from the vessels to the sorting pad area by forklifts. The sorting pad is surrounded by large shipping containers (approximately 5 feet x 20 feet), each for a specific type of metal.

The sorting pad worker removes the individual pieces of metal from the scrap bin by hand. The worker makes a determination of the type of metal in hand and then carries the item to the appropriate shipping container. The worker then places or throws the item into the shipping container and returns to the scrap bin for the next item. Each bin takes approximately 20 minutes to empty and sort. Individual items can weigh anywhere from a few ounces for metal strapping to in excess of fifty pounds for triple valve assemblies.



Figure 4. Worker Reaching to Bottom of Scrap Bin to Retrieve Item



Figure 5. Worker Hanging Over Edge of Scrap Bin and On One Leg



Figure 6. Working Lifting Triple Valve Assembly from Sorting Bin



Figure 7. Worker Carrying Triple Valve Assembly to Shipping Container

### **IIIA2. Ergonomic Risk Factors for Sorting Pad Worker**

The Sorting pad worker often must reach far in front or deep into the bin while grasping objects of unknown weight. Awkward postures of the back and neck, such as extreme lumbar flexion and neck extension, are fairly common. Strain of the shoulder, neck, and back are possible due

to the manual lifting tasks. Some items are relatively heavy resulting in increased physiological strain on the worker.

### **IIIA3. Ergonomic Analysis of Bin Emptying Task on Drydock Sorting Pad**

Using several of the exposure assessment tools outlined previously, an ergonomic analysis was performed for the sorting pad worker emptying scrap bins. A Strain Index analysis was performed for the sorting pad worker (Table 1) with the following results:

- 1) the Intensity of Exertion was rated as “Hard” and given a multiplier score of 6 on a scale of 1 to 13
- 2) the Duration of the task was rated as equal to or greater than 80 % of the task cycle, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 3) the Efforts per Minute were noted to be between 15 and 19, resulting in a multiplier of 2.0 on a scale of 0.5 to 3.0
- 4) the Hand/Wrist posture was rated as “Fair,” resulting in a multiplier of 1.5 on a scale of 1.0 to 3.0
- 5) the Speed of Work was rated as “Normal,” resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
- 6) the Duration of Task per Day was rated to be between 2 and 4 hours, resulting in a multiplier of 0.75 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For this task the SI score was 40.5. An SI Score of between 31 and 60 is correlated to an incidence rate of about 106 distal upper extremity injuries per 100 FTE. Regardless of actual incidence rate, the Strain Index indicates that this task puts the sorting pad worker at an increased risk of developing a distal upper extremity injury.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the sorting pad worker bin emptying task (Table 2), of the 21 possible responses, nine were negative and seven were positive (one question answered both positively and negatively, six questions were not applicable. Negative responses, in this case 56 %, are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the sorting pad worker (Table 3), the need for corrective measures was suggested for a number of specific sub-tasks including: lifting items from the scrap bin, carrying items to the shipping containers, and scraping labels off the scrap bins.

The NIOSH checklist for manual materials handling consists of 14 items. When applied to the sorting pad worker bin emptying task (Table 4), six responses were positive and eight negative. In this checklist, positive responses are indicative of conditions that pose a risk to the worker of developing low back pain. The higher the percentage of positive response, the greater the risk of low back pain.

The University of Michigan 3D Static Strength Prediction Program was used to analyze the sorting pad worker lifting a triple valve assembly from the bottom of a scrap bin (Table 5). Analysis of this sub-task resulted in an estimated disc compression loads at the L5/S1 disc to be 972 pounds, well above the NIOSH Recommended Compression Limit of 770 pounds.

The PLIBEL checklist for the sorting pad worker task (Table 6) reports a high percentage (~ 75 %) of risk factors present for the neck, shoulders, upper back, and lower back, and a moderate percentage (~ 60 %) of risk factors present for the elbows, forearms, and hands. Several environmental and organizational modifying factors are present as well.

### **IIIB. Insulation Removal on Surface Ship in Drydock**



Figure 8. Worker Removing Insulation Tie Cap with Short Pry Bar

#### **IIIB1. Insulation Removal Process**

Insulation from the bulkheads and ceilings of vessels being dismantled is removed by insulators. The workers first cordon off the immediate work area to discourage entry by unauthorized personnel. This action is done by hanging warning tape and placards (e.g., “WARNING Man-Made Vitreous Fibers”) around the work area. The insulators don totally encapsulating chemical protective suits and supplied-air hoods under positive pressure. The initial task of the worker is to remove the insulation tie caps. These small, round disks secure the insulation onto the metal insulation studs. These disks are removed using pry bars or wrecking bars of various sizes while standing on ladders to reach the overhead insulation.



Figure 9. Insulator Removing Insulation Tie Cap Overhead



Figure 10. Insulator Removing Insulation Tie Cap with Short Bar

Once all the insulation tie caps have been removed, the worker uses a hawksbill knife (i.e., a knife with a short, downward-curved blade) to cut the insulation into manageable widths of approximately 18 inches. While cutting into the insulation, a co-worker sprays the surrounding air with a water mist to entrap any loose fibers that may otherwise be respirable.



Figure 11. Insulation Worker Using Knife to Cut Insulation



Figure 12. Insulation Worker Cutting into Insulation with Hawksbill Knife

The worker then pulls on the insulation to break it free from the bulkhead or overhead area. The insulation is bagged and disposed of properly.



Figure 13. Pulling Insulation Off Overhead Area by Hand



Figure 14. Pulling Section of Insulation Off Bulkhead by Hand

### **IIIB2. Ergonomic Risk Factors for Insulation Removal Workers**

The vast majority of work for the insulation removal workers is performed with arms overhead or out in front and away from the body, either using pry bars or knives, straining the arms, shoulders, and neck. Often the worker is on a ladder and is leaning backward (back extension) to get to the work as opposed to repositioning the ladder. Back extension such as this can be stressful to the worker. Pulling the insulation off the bulkheads or overhead areas requires the

use of force to separate the insulation from the surface areas. This task is stressful to the arms, shoulders, neck and back. All of these tasks are performed while the worker is wearing an encapsulating chemical-protective suit with a supplied air respirator causing an increased physiological strain on the worker.

### **IIIB3. Ergonomic Analysis of Insulation Removal Workers**

Using several of the exposure assessment tools outlined previously, an ergonomic analysis was conducted for the tasks of the insulation removal worker. A Rapid Upper Limb Assessment analysis was conducted for the insulation removal workers (Table 7). Five separate tasks were analyzed: 1) using a small pry bar to remove insulation tie caps, 2) using a hawkbill knife to cut the insulation, 3) using a crowbar to pry insulation off the bulkhead, 4) using two hands to pull insulation down, and 5) moving the ladder to the next location. Tasks # 1, 2, and 3 resulted in a response to “investigate and change immediately.” Task # 4 resulted in a response to “investigate and change soon.” Task # 5 resulted in a response to “investigate further.”

A Strain Index analysis was performed for the insulation removal worker (Table 8) with the following results:

- 1) the Intensity of Exertion was rated as “Very Hard” and given a multiplier score of 9 on a scale of 1 to 13
- 2) the Duration of the task was rated as equal to or greater than 80 % of the task cycle, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 3) the Efforts per Minute were noted to be greater than 20 per minute, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 4) the Hand/Wrist posture was rated as “Bad,” resulting in a multiplier of 2.0 on a scale of 1.0 to 3.0
- 5) the Speed of Work was rated as “Normal,” resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
- 6) the Duration of Task per Day was rated to be between 2 and 4 hours, resulting in a multiplier of 0.75 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For the insulation removal tasks the SI score was 121.5. An SI Score greater than 60 is correlated to an incidence rate of about 130 distal upper extremity injuries per 100 FTE. Regardless of actual incidence rate, the Strain Index indicates that this task puts the insulation removal worker at an increased risk of developing a distal upper extremity injury.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the insulation removal worker tasks (Table 9), of the 21 possible responses, eighteen were negative and four were positive (one question answered both positively and negatively). Negative responses, in this case 82 %, are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the insulation removal tasks (Table 10), the need for corrective measures “as soon as possible” was suggested for the task of removing the insulation tie caps with a small pry bar. Four other tasks called for corrective measures “in the near future” including: moving the ladder, cutting the insulation with a hawksbill knife, loosening the insulation with a small pry bar, and pulling the insulation off the bulkheads and overhead areas by hand.

The PLIBEL checklist for the insulation removal tasks (Table 11) reports a very high percentage (~ 91 %) of risk factors present for the elbows, forearms and hands. A moderate percentage (~ 45-62 %) of risk factors were reported present for the neck, shoulders, upper back and lower back. Several environmental and organizational modifying factors are present as well.

### **IIIC. Reciprocating Saw Operations in the IRR Process**



Figure 15. Two-Person Cutting Operation for Ductwork with Possible Hazardous Material

#### **IIIC1. Cutting Process with Reciprocating Saws**

Ship dismantling, or Inactivation, Reactor Compartment Disposal, and Recycling as the process is known by at PSNS, requires the separation of components, bulkheads, and hull sections from adjoining locations. This separation is accomplished either by torch cutting or by using a reciprocating saw to cut through the steel, aluminum or other material. Torch cutting requires a fire-watch crew to stand by and a certain level of expertise by the user. Cutting with a reciprocating saw does not require the fire-watch crew and can be accomplished by nearly every worker making it the preferred method among supervisors. Also, areas containing suspected hazardous materials must be mechanically cut to minimize worker exposure to the substance. Chemical protective clothing is worn when there is the possibility of exposure to known hazards. Mechanical cutting can take place overhead to remove wire hangers, between shoulder and floor

height to remove bulkheads, or below floor level to remove decking and supports. Some components are lowered to the deck to be cut to reduce the amount of overhead work.



Figure 16. Worker Using Reciprocating Saw While Kneeling



Figure 17. Kneeling Worker Changing Blade on Reciprocating Saw

Workers assume a variety of postures to cut the pieces of metal including kneeling, sitting, lying down, bending over, standing on ladders, etc. Workers typically cut for 2-3 hours and then carry cut material to a disposal area for another 2 hours. Workers often work in pairs, switching between cutting the material with the eight pound reciprocating saw and supporting the item

being cut. Heavier items are removed using tandem lifts.



Figure 18. Kneeling Workers Planning Next Cut Sequence



Figure 19. Kneeling Workers Adjusting Position of Ductwork Being Cut

### **IIIC2. Ergonomic Risk Factors for Reciprocating Saw Operators**

The ergonomic risk factors for reciprocating saw operators include: awkward postures of the spine and wrist, static kneeling postures, forceful exertion of the upper extremity to hold the reciprocating saw, and high noise exposure. Particularly significant is the exposure to hand-arm or segmental vibration from using the powered reciprocating saw. (Vibration damping gloves are

required personal protective equipment while using the saw). Normal operation of the saw results in vibration that has been reduced by an anti-vibration mechanism incorporated into the design of the saw. However, when initiating a cut (plunge cutting) or when the blade binds in the material, an extreme amount of vibration is transferred to the arm of the user. The manual material handling of the cut pieces may result in back, neck or shoulder strain of the workers.

### **IIIC3. Ergonomic Analysis of Reciprocating Saw Operator Tasks**

A Rapid Upper Limb Assessment analysis was conducted for the reciprocating saws operator tasks (Table 12). Five separate tasks were analyzed: 1) sawing while kneeling, 2) sawing while standing, 3) changing saw blade while kneeling, 4) kneeling and planning next cut with co-worker, and 5) manually lifting piece to reposition item. Tasks # 1, 2, 3, and 5 resulted in a response to “investigate and change immediately.” Task # 4 resulted in a response to “investigate further.”

A Strain Index analysis was performed for the reciprocating saw worker (Table 13) with the following results:

- 1) the Intensity of Exertion was rated as “Hard” and given a multiplier score of 6 on a scale of 1 to 13
- 2) the Duration of the task was rated as equal to or greater than 80 % of the task cycle, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 3) the Efforts per Minute were noted to be greater than 20 per minute, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 4) the Hand/Wrist posture was rated as “Bad,” resulting in a multiplier of 2.0 on a scale of 1.0 to 3.0
- 5) the Speed of Work was rated as “Normal,” resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
- 6) the Duration of Task per Day was rated to be between 2 and 4 hours, resulting in a multiplier of 0.75 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For the reciprocating saw worker tasks the SI score was 81. An SI Score greater than 60 is correlated to an incidence rate of about 130 distal upper extremity injuries per 100 FTE. Regardless of actual incidence rate, the Strain Index indicates that this task puts the reciprocating saw worker at an increased risk of developing a distal upper extremity injury.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the reciprocating saw worker tasks (Table 14), of the 21 possible responses, sixteen were negative and six were positive (one question answered both positively and negatively). Negative responses, in this case 73 %, are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the reciprocating saw worker tasks (Table 15), the

need for “corrective measures in the near future” was suggested for six of the eight tasks analyzed. These tasks were: sawing while kneeling, sawing while standing, changing the blade while kneeling and repositioning the saw, body, or workpiece.

The NIOSH checklist for manual materials handling consists of 14 items. When applied to the reciprocating saw worker tasks (Table 16), six responses were positive and eight negative. In this checklist, positive responses (43 %) are indicative of conditions that pose a risk to the worker of developing low back pain. The higher the percentage of positive response, the greater the risk of low back pain.

The PLIBEL checklist for the reciprocating saw worker tasks (Table 17) reports a very high percentage (~ 82 %) of risk factors present for the elbows, forearms and hands. A moderate percentage (~ 57-65 %) of risk factors were reported present for the neck, shoulders, upper back and lower back. Several environmental and organizational modifying factors are present as well.

### **IIID. Tile Chipping Operations**



Figure 20. Worker Using Chipping Hammer to Remove Terrazzo Tile from Deck Surface

#### **IIID1. Removal of Terrazzo Tile with Chipping Hammer**

During the outfitting of vessels, some of the decking surfaces are covered in tile. This is particularly true of mess hall and lavatory facilities. Before the deck plate can be cut by either torch or reciprocating saw, a path must be cleared of tile. The tile is removed by using a chipping hammer to break the tile and flake the tile off the deck surface. This task requires the worker to kneel, sit or bend over the deck surface to operate the chipping hammer.



Figure 21. Working Using Chipping Hammer Nearly Parallel to Tile



Figure 22. Worker Brushing Away Chipped Tile Shards

### **IIID2. Ergonomic Risk Factors for Tile Chipping Worker**

Chipping tile from deck surfaces puts the worker in awkward postures, having to kneel or sit on the deck. The back and neck are flexed. Exposure to hand-arm or segmental vibration is bad, having to hold the chipping blade in place with one hand while holding the tool weight and operating the trigger with the other hand. Few improvements to these tools have been made since the turn of the century. Noise exposure is also very high with the use of chipping hammers.

### IIID3. Ergonomic Analysis of Tile Chipping Tasks

A Rapid Upper Limb Assessment analysis was conducted for the tile chipping tasks (Table 18). Five separate tasks were analyzed: 1) chipping perpendicular to tile, 2) chipping parallel to tile, 3) re-positioning the chipping hammer, 4) brushing aside broken tile shards, and 5) re-positioning the worker's body. Tasks # 1, 2, and 3 resulted in a response to "investigate and change immediately." Tasks # 4 and 5 resulted in a response to "investigate further."

A Strain Index analysis was performed for the tile chipping saw worker (Table 19) with the following results:

- 1) the Intensity of Exertion was rated as "Hard" and given a multiplier score of 6 on a scale of 1 to 13
- 2) the Duration of the task was rated as equal to or greater than 80 % of the task cycle, resulting in a multiplier of 3.0 on a scale of 0.5 to 3.0
- 3) the Efforts per Minute were noted to be about 12.5 times per minute, but were also quite static. A compromise rating was given, resulting in a multiplier of 2.0 on a scale of 0.5 to 3.0
- 4) the Hand/Wrist posture was rated as "Bad," resulting in a multiplier of 2.0 on a scale of 1.0 to 3.0
- 5) the Speed of Work was rated as "Normal," resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
- 6) the Duration of Task per Day was rated to be between 2 and 4 hours, resulting in a multiplier of 0.75 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For the tile chipping tasks the SI score was 54. An SI Score between 30 and 60 is correlated to an incidence rate of about 106 distal upper extremity injuries per 100 FTE. Regardless of actual incidence rate, the Strain Index indicates that this task puts the tile chipping worker at an increased risk of developing a distal upper extremity injury.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the tile chipping tasks (Table 20), of the 21 possible responses, seventeen were negative and five were positive (one question answered both positively and negatively). Negative responses, in this case 77 %, are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the tile chipping tasks (Table 21), the need for "corrective measures in the near future" was suggested for five of the six tasks analyzed. These tasks were: chipping perpendicular to tile, chipping parallel to tile, brushing away loose tile, and repositioning the chipping hammer or the body.

The NIOSH checklist for manual materials handling consists of 14 items. When applied to the tile chipping tasks (Table 22), six responses were positive and eight negative. In this checklist,

positive responses (43 %) are indicative of conditions that pose a risk to the worker of developing low back pain. The higher the percentage of positive response, the greater the risk of low back pain.

The PLIBEL checklist for the tile chipping tasks (Table 23) reports a very high percentage (~ 82 %) of risk factors present for the elbows, forearms and hands. A moderate percentage (~ 47-65 %) of risk factors were reported present for the neck, shoulders, upper back and lower back. Several environmental and organizational modifying factors are present as well.

### **IIIE. Manual Material Handling in the “Cut and Carry” Process within IRR**



Figure 23. Workers Performing Tandem Lift of Scrap Material Inside Vessel

#### **IIIE1. Manual Material Handling in Ship Dismantling Tasks**

As part of the Inactivation, Reactor Compartment Disposal, and Recycling process at PSNS, material is cut apart and stored at temporary locations within the vessel being dismantled. This material is then manually moved from the internal storage areas to scrap bins for removal from the ship by crane. Depending on how the material was cut, it may require more than one individual to safely lift the object and carry it to the scrap bin. Somewhat confined spaces and the clutter of the stored material create tripping hazards in the narrow passageways.



Figure 24. Worker Pulling Scrap Loose from Pile



Figure 25. Moving Scrap Material from Storage Pile



Figure 26. Workers Placing Scrap in Bin for Transport Off Ship

### **IIIE2. Ergonomic Risk Factors for Manual Material Handling Workers**

The manual material handling of scrap metal may result in strains of the lower back, neck, shoulder and upper extremities. Tripping hazards may be present. Sharp edges on the cut metal may cause lacerations to ungloved hands.

### **IIIE3. Ergonomic Analysis of Carrying Tasks in Ship Dismantling**

A Strain Index analysis was performed for the manual material handling tasks in the “cut and carry” operation (Table 24) with the following results:

- 1) the Intensity of Exertion was rated as “Somewhat Hard” and given a multiplier score of 3 on a scale of 1 to 13
- 2) the Duration of the task was rated as being between 30 and 49 percent of the task cycle, resulting in a multiplier of 1.5 on a scale of 0.5 to 3.0
- 3) the Efforts per Minute were noted to be less than 4 per minute, resulting in a multiplier of 0.5 on a scale of 0.5 to 3.0
- 4) the Hand/Wrist posture was rated as “Fair,” resulting in a multiplier of 1.5 on a scale of 1.0 to 3.0
- 5) the Speed of Work was rated as “Normal,” resulting in a multiplier of 1.0 on a scale of 1.0 to 2.0
- 6) the Duration of Task per Day was rated to be between 2 and 4 hours, resulting in a multiplier of 0.75 on a scale of 0.25 to 1.50.

The multiplier values for each segment are multiplied together resulting in a final Strain Index (SI) score. For the manual material handling tasks, the SI score was 2.5. An SI Score less than 5

is correlated to an incidence rate of about 2 distal upper extremity injuries per 100 FTE.

In applying the University of Michigan Upper Extremity Cumulative Trauma Disorder Checklist to the reciprocating saw worker tasks (Table 25), of the 21 possible responses, nine were negative and six were positive, and 6 were not applicable (one question answered both positively and negatively). Negative responses, in this case 60 %, are indicative of conditions associated with the risk of developing cumulative trauma disorders.

When the OWAS technique was applied to the manual material handling tasks (Table 26), the need for “corrective measures in the near future” was suggested for only two of the seven tasks analyzed. These tasks were arranging items in the scrap bin and lifting materials.

The NIOSH checklist for manual materials handling consists of 14 items. When applied to the reciprocating saw worker tasks (Table 27), five responses were positive and nine negative. In this checklist, positive responses (36 %) are indicative of conditions that pose a risk to the worker of developing low back pain. The higher the percentage of positive response, the greater the risk of low back pain.

The University of Michigan 3D Static Strength Prediction Program was used to analyze a variety of manual material handling tasks performed in the “cut and carry” operation (Table 28). Analysis of these sub-task resulted in estimated disc compression loads at the L5/S1 disc ranging from 311.8 pounds for a tandem lift of 40 pounds to 741.4 pounds for lifting a 40 pound item within the scrap bin. All results were below the NIOSH Recommended Compression Limit of 770 pounds.

The PLIBEL checklist for the manual material handling tasks in the “cut and carry” operation (Table 29) reports a moderate percentage (~ 50-67 %) of risk factors were reported present for the neck, shoulders, upper extremities, lower extremities, upper back and lower back. Several environmental and organizational modifying factors are present as well.

#### **IV. CONTROL TECHNOLOGY**

Possible interventions and control technologies are mentioned briefly here. A more detailed report of possible interventions is in preparation.

##### **IVA. Bin Emptying by Sorting Pad Worker Possible Interventions**

Changes in how the scrap bins are presented to the worker may help in eliminating the extreme back flexion required to reach to the bottom of the bins to remove items. Tilting pallet jacks can be used to tilt the scrap bin once some of the material has been distributed to the shipping containers. The scrap material can be dumped from the bins onto an elevated rotating turntable. This elevated turntable would minimize the need of the worker to bend into the bins to remove

materials. Short hooked poles can be provided to move material from the center of the table to the edge to allow the worker to grasp it. Ultimately, the accurate sorting of material into separate scrap bins at the vessel would eliminate the need for the sorting pad.

#### **IVB. Insulation Removal Possible Interventions**

A high percentage of the insulation removal tasks require the worker to stand on ladders and work overhead. Elevated work platforms would provide a more stable standing surface than ladders. The platforms may be elevated close to the ceiling to allow the worker to lay down and work with arms in front of the body as opposed to working above shoulder height. Removal of the insulation tie caps with a pry bar can be replaced with mechanical cutters.

#### **IVC. Reciprocating Saw Operators Possible Interventions**

The use of reciprocating saws can be minimized by the increase in use of torch cutting. Time savings in length of time require to complete the cut in part offsets the requirement for a fire-watch crew. If saws are utilized, the use of wheeled tripods or standing jigs as developed at PSNS will remove the worker from the vibration exposure. The addition of a stabilizing handle near the front of the tool that isolates some of the vibration from the worker is also a good idea. Modifying the saw trigger mechanism to work from palm pressure as opposed to finger pressure was also done at PSNS to minimize trigger finger complaints.

#### **IVD. Tile Chipping Possible Interventions**

Removing tile from deck surfaces requires the worker to kneel or sit on the deck. Providing kneel pads or cushions minimizes some of the contact stresses. If chipping hammers can not be replaced as the tool of choice, it is recommended that the widest blade possible be used on the hammer to minimize exposure time

#### **IVE Manual Material Handling in “Cut and Carry” Operation Possible Interventions**

Ship dismantling requires that all internal components are remove from the vessel before it is cut to pieces. The removal of components through ship passageways to staging areas is currently performed by manual material handling. There is the possibility that flexible conveyor systems can be used to either move material to the staging area or to move material into the scrap bins in the staging areas. Portable hoists may be useful in the staging areas as well to move heavy or bulky material.

## **V. CONCLUSIONS AND RECOMMENDATIONS**

Five distinct work processes within a ship dismantling operation were surveyed to determine the presence of risk factors associated with musculoskeletal disorders. Each work process was analyzed using a number of exposure assessment techniques. Possible interventions highlighted here for the five work tasks analyzed will be discussed in much greater detail in a forthcoming report.

It is recommended that further action be taken to mitigate the exposure to musculoskeletal risk factors within each of the identified tasks. The implementation of ergonomic interventions has been found to reduce the amount and severity of musculoskeletal disorders within the working population in various industries. It is recommended that ergonomic interventions be implemented at Puget Sound Naval Shipyard to minimize hazards in the identified job tasks.

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## **APPENDIX**

### **TABLES**

## A1. Sorting Pad Worker

Table 1. Sorting Pad Worker Strain Index

*STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT*  
(Moore and Garg, 1995)

LOCATION: Puget Sound Naval Shipyard Sorting Pad, 10/21/99

TASK: Bin emptying by sorting pad worker

1. <b>Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
<b>Rating Criterion</b>	<b>% MS</b> (percentage of maximal strength)	<b>Borg Scale</b> (Compare to Borg Cr-10 Scale)	<b>Perceived Effort</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
Somewhat hard	10 - 29%	3	noticeable or definite effort	2	3
<b>Hard</b>	<b>30 - 49%</b>	<b>4 - 5</b>	<b>obvious effort; unchanged facial expression (*28 -38% of observed time &gt; = Hard)</b>	<b>3</b>	<b>6</b>
Very Hard	50 - 79%	6 - 7	substantial effort; changes to facial expression	4	9
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
<b>Intensity of Exertion Multiplier</b>					<b>6</b>

Table 1 (continued). Sorting Pad Worker Strain Index

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  % Duration of Exertion  $= 100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$  $= 100 \times \frac{993 \text{ (sec)}}{1168 \text{ (sec)}}$ $= 85$	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 10	1	0.5
	10 - 29	2	1.0
	30 - 49	3	1.5
	50 - 79	4	2.0
	<b>&gt; or = 80</b>	<b>5</b>	<b>3.0</b>
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  Efforts per Minute  $= \frac{\text{number of exertions}}{\text{Total observation time (min)}}$  $= \frac{[\text{total \# of efforts for observed period, 298}]}{[\text{Total observed time (min) 19.46}]}$ $= 15.31$	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 4	1	0.5
	4 - 8	2	1.0
	9 - 14	3	1.5
	<b>15 - 19</b>	<b>4</b>	<b>2.0</b>
	<b>&gt; or = 20</b>	<b>5</b>	<b>3.0</b>
<b>Efforts per Minute Multiplier</b>			<b>2.0</b>

Table 1 (continued). Sorting Pad Worker Strain Index

<b>4. Hand/ Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
<i><b>Rating Criterion</b></i>	<i><b>Wrist Extension</b></i> (Stetson et al, 1991)	<i><b>Wrist Flexion</b></i> (Stetson et al, 1991)	<i><b>Ulnar Deviation</b></i> (Stetson et al, 1991)	<i><b>Perceived Posture</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
<b>Fair</b>	<b>26 -40 degrees</b>	<b>16 - 30 degrees</b>	<b>16 - 20 degrees</b>	<b>non-neutral</b>	<b>3</b>	<b>1.5</b>
Bad	41 - 55 degrees	31 - 50 degrees	21 -25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<i><b>Hand/ Wrist Posture Multiplier</b></i>						<b>1.5</b>

Table 1 (continued). Sorting Pad Worker Strain Index

5. <b>Speed of Work:</b> An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
<i>Rating Criterion</i>	<i>Compared to MTM</i> -1 (observed pace is divided by MTM's predicted pace and expressed as % ; See Barnes 1980)	<i>Perceived Speed</i>	<i>Rating</i> (circle)	<i>Multiplier</i>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	"taking one's own time"	2	1.0
<b>Fair</b>	<b>91 -100%</b>	<b>"normal" speed of motion</b>	<b>3</b>	<b>1.0</b>
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
<i>Speed of Work Multiplier</i>				<b>1.0</b>

6. <b>Duration of Task per Day:</b> Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
<i>Worksheet:</i>	<i>Rating Criterion</i>	<i>Rating</i> (circle)	<i>Multiplier</i>
Duration of Task per Day (hrs)  = duration of task (hrs) + duration of task (hrs) + ....	< or = 1 hrs	1	0.25
	1 - 2 hrs	2	0.50
	<b>2 - 4 hrs</b>	<b>3</b>	<b>0.75</b>
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
	<i>Duration of Task per Day Multiplier</i>		<b>0.75</b>

Table 1 (continued). Sorting Pad Worker Strain Index

<b>Calculate the Strain Index (SI) Score:</b> Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.						
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/ Wrist Posture	Speed of Work	Duration of Task	
<u>6</u> x	<u>3</u> x	<u>2</u> x	<u>1.5</u> x	<u>1</u> x	<u>.75</u>	=
						<b><u>SI SCORE</u></b> <u>40.5</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;
- SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table 2. Sorting Pad Worker UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders* (Lifshitz and Armstrong, 1986)

Date/ Time 10/21/99

Facility Puget Sound

Area/ Shop: Drydock

Task Bin Sorting

\* "No" responses are indicative of conditions associated with the risk of CTD's

<u>Risk Factors</u>	<u>No</u>	<u>Yes</u>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N*	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N/A	N/A
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N/A	N/A
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N/A	N/A
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	N/A	N/A
6.3 Is the handle of the tool made from material other than metal?	N/A	N/A
6.4 Is the weight of the tool below 4 kg (9lbs)?	N/A	N/A
6.5 Is the tool suspended?	N/A	N/A
<b>TOTAL</b>	9 (56%)	7 (44%)

Table 3. Sorting Pad Worker OWAS

OWAS: *OVAKO Work Analysis System* (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 10/21/99  
Area/ Shop: Drydock

Facility Puget Sound Naval Shipyard  
Task: Scrap Bin Sorting

	Work Phase 1: Lifting piece from receiving bin	Work Phase 2 Carrying piece to separator bin	Work Phase 3 Throwing piece into separate bin	Work Phase 4 Walking back to receiving bin	Work Phase 5 Sweeping out receiving bin	Work Phase 6 Scraping labels off receiving bin	Work Phase 7 Cutting off zip ties
<b><i>TOTAL Combination Posture Score</i></b>	<b><i>3</i></b>	<b><i>3</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>4</i></b>	<b><i>1</i></b>
<b>Common Posture Combinations (collapsed across work phases)</b>							
Back	2	2	4	4	1	4	1
Arms	1	1	1	1	1	1	1
Legs	2	3	2	3	7	4	2
<b>Posture Repetition</b> (% of working time)	38*	38*	38*	38*	56	3	1
<b><i>BACK % of Working Time SCORE</i></b>	<b><i>2</i></b>	<b><i>2</i></b>	<b><i>3</i></b>	<b><i>3</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>
<b><i>ARMS % of Working Time SCORE</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>
<b><i>LEGS % of Working Time SCORE</i></b>	<b><i>1</i></b>	<b><i>2</i></b>	<b><i>1</i></b>	<b><i>2</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>
<b><i>ACTION CATEGORIES:</i></b> <b><i>1 = no corrective measures</i></b> <b><i>2 = corrective measures in the near future</i></b> <b><i>3 = corrective measures as soon as possible</i></b> <b><i>4 = corrective measures immediately</i></b>							

**Table 3 (continued). Sorting Pad Worker OWAS**

<b>Risk Factor</b>	<b>Work Phase 1: Lifting piece from receiving bin</b>	<b>Work Phase 2 Carrying piece to separator bin</b>	<b>Work Phase 3 Throwing piece into separate bin</b>	<b>Work Phase 4 Walking back to receiving bin</b>	<b>Work Phase 5 Sweeping out receiving bin</b>	<b>Work Phase 6 Scraping labels off receiving bin</b>	<b>Work Phase 7 Cutting off zip ties</b>
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2, 4	1	1	1	1	4	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2,3	7	7	7	7	4	2
<b>Load/ Use of Force</b>							
1 = weight or force needed is = or <10 kg 2 = weight or force > 10 but < 20kg 3 = weight or force > 20 kg	3	3	3	1	1	1	1
<b>Phase Repetition</b>							
% of working time (0,10,20,30,40,50,60,70,80,90,100)	38	13	13	14	16	03	01

Table 4. Sorting Pad Worker NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
(Waters and Putz-Anderson, 1996)

Date/ Time 10/21/99

Facility Puget Sound Naval Shipyard

Area/ Shop: Drydock Sorting Pad

Task: Scrap Bin Sorting

RISK FACTORS	YES	NO
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?	Y (sometimes)	
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?		N
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?	Y	
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extreme lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?		N (cold, heat occasionally)
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 4.5 over total cycle time, but some multiple lifts are counted singly)
2.2 Does the vertical lifting distance exceed 3 feet?	Y (sometimes)	
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?		N (usually @ 5-10)
2.5 Do extended reach static holding tasks exceed 1 minute?		N
<b>TOTAL</b>	6 (43%)	8 (57%)

\* "YES" responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of "YES" responses, the greater the risk.

Table 5. Sorting Pad Worker 3D Static Strength Prediction Program

*3D Static Strength Prediction Program* (University of Michigan, 1997)

*Date/ Time:* 10/21/99

*Area/ Shop:* Drydock Sorting Pad

*Facility:* Puget Sound Naval Shipyard

*Task:* Scrap Bin Sorting

<b>Work Element:</b> Scrap Bin Sorting	<b>Disc Compression (lbs) @ L5/S1</b> (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
<b>Two-handed lift from the bottom of the scrap bin, supported on one leg.</b> Item (triple valve assembly) weighs 70 lbs.	<b>972 lbs.</b> (beginning of lift)

Table 6. Sorting Pad Worker PLIBEL

*PLIBEL Checklist* (Kemmlert, 1995)

Date/ Time: 10/21/99  
Area/ Shop: Plate Shop

Facility: Puget Sound Naval Shipyard  
Task: Scrap Bin Sorting

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
<i>Musculoskeletal Risk Factor Questions</i>	<i>Body Regions</i>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	Y				Y

Table 6 (continued). Sorting Pad Worker PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	Y				Y
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table 6 (continued). Sorting Pad Worker PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	20	7	2	2	15
PERCENTAGE	76.9	63.6	25.0	25.0	71.4
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	4				
PERCENTAGE	40.0				

## A2. Insulators

Table 7. Insulators RULA

*Rapid Upper Limb Assessment (RULA) (Matamney and Corlett, 1993)*

Date/Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Vessel in Drydock

Task : Removal of Insulation from Bulkhead Surfaces

RULA Component	Frame # 53939 Using small crow-bar to pop off insulating tie caps overhead (standing on ladder)		Frame # 67499 Using hawkbill knife to cut insulation (overhead)		Frame # 68850 Using small crowbar to pry off insulation		Frame # 72030 Pulling insulation off by hand		Frame # 59220 Moving ladder	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	hyp flex	4	hyp flex	4	hyp flex	4	hyp flex	4	sl flex	2
Shoulder is Raised (+1)		1		1		1		1		0
Upper Arm Abducted (+1)		1		1		1		1		1
Arm supported, leaning (-1)		0		0		0		0		0
Elbow Extension/ Flexion	ext	1	neut	2	ext	1	ext	1	neut	2
Shoulder Abduction/ Adduction	m abd	1	m abd	1	m abd	1	m abd	1	m abd	1
Shoulder Lateral/ Medial	lat	1	lat	1	neut	0	lat	1	lat	1
Wrist Extension/ Flexion	ext	2	flx	2	ext	2	flx	2	neut	1
Wrist Deviation	ulnar	1	rad	1	rad	1	ulnar	1	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range Or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		0
Arm and Wrist Force/ load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		3		3		3		3		1

Table 7 (continued). Insulators RULA

Neck Extension/ Flexion		2		2		2		2		2
Neck Twist (+1)		1		1		0		0		0
Neck Side-Bent (+1)		1		1		0		0		0
Trunk Extension/ Flexion	ext	1	neut	1	ext	1	neut	1	sl flex	2
Trunk Twist (+1)		1		0		0		0		0
Trunk Side Bend (+1)		1		0		0		0		0
Legs If legs and feet are supported and balanced: ( +1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		0
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		1
<b>Total RULA Score</b>	<b>7</b>	<b>7</b>		<b>7</b>		<b>6</b>		<b>3</b>		
<b>1 or 2 = ACCEPTABLE</b> <b>3 or 4 = INVESTIGATE FURTHER</b> <b>5 or 6 = INVESTIGATE FURTHER AND CHANGE SOON</b> <b>7 = INVESTIGATE AND CHANGE IMMEDIATELY</b>										

Table 8. Insulators Strain Index

*STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT*  
(Moore and Garg, 1995)

LOCATION: Puget Sound Naval Shipyard Surface Ship in Drydock, 10/21/99

TASK: Removal of Insulation from Bulkheads and Systems

1. <b>Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
<b>Rating Criterion</b>	<b>% MS</b> (percentage of maximal strength)	<b>Borg Scale</b> (Compare to Borg Cr-10 Scale)	<b>Perceived Effort</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
Somewhat hard	10 - 29%	3	noticeable or definite effort	2	3
Hard	30 - 49%	4 - 5	obvious effort; unchanged facial expression	3	6
<b>Very Hard</b>	<b>50 - 79%</b>	<b>6 - 7</b>	<b>substantial effort; changes to facial expression (79% of observed time &gt; = Hard, due to overhead work)</b>	<b>4</b>	<b>9</b>
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
<b>Intensity of Exertion Multiplier</b>					<b>9</b>

Table 8 (continued). Insulators Strain Index

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  % Duration of Exertion  $= 100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$ $= 100 \times \frac{2066 \text{ (sec)}}{2289 \text{ (sec)}}$ $= 90$	<b>Rating Criterion</b>  < 10  10 - 29  30 - 49  50 - 79  > or = 80	<b>Rating</b>  1  2  3  4  5	<b>Multiplier</b>  0.5  1.0  1.5  2.0  3.0
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  Efforts per Minute  $= \frac{\text{number of exertions}}{\text{Total observation time (min)}}$ $= \text{nearly static exertion, therefore multiplier} = 3$	<b>Rating Criterion</b>  < 4  4 - 8  9 - 14  15 - 19  > or = 20	<b>Rating</b>  1  2  3  4  5	<b>Multiplier</b>  0.5  1.0  1.5  2.0  3.0
<b>Efforts per Minute Multiplier</b>			<b>3.0</b>

Table 8 (continued). Insulators Strain Index

4. <b>Hand/ Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
<i><b>Rating Criterion</b></i>	<i><b>Wrist Extension</b></i> (Stetson et al, 1991)	<i><b>Wrist Flexion</b></i> (Stetson et al, 1991)	<i><b>Ulnar Deviation</b></i> (Stetson et al, 1991)	<i><b>Perceived Posture</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
Fair	26 -40 degrees	16 - 30 degrees	16 - 20 degrees	non-neutral	3	1.5
<b>Bad</b>	<b>41 - 55 degrees</b>	<b>31 - 50 degrees</b>	<b>21 -25 degrees</b>	<b>marked deviation (*estimated, based on RULA performed)</b>	<b>4</b>	<b>2.0</b>
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/ Wrist Posture Multiplier</b>						<b>2.0</b>

Table 8 (continued). Insulators Strain Index

5. <b>Speed of Work:</b> An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
<b>Rating Criterion</b>	<b>Compared to MTM</b> -1 (observed pace is divided by MTM's predicted pace and expressed as %; See Barnes 1980)	<b>Perceived Speed</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	"taking one's own time"	2	1.0
<b>Fair</b>	<b>91 -100%</b>	<b>"normal" speed of motion</b>	<b>3</b>	<b>1.0</b>
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

6. <b>Duration of Task per Day:</b> Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Duration of Task per Day (hrs)  = duration of task (hrs) + duration of task (hrs) + ....  = (estimate @2-4 hrs; must check w mgmt*** )	< or = 1 hrs	1	0.25
	1 - 2 hrs	2	0.50
	<b>2 - 4 hrs</b>	<b>3</b>	<b>0.75</b>
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
	<b>Duration of Task per Day Multiplier</b>		<b>0.75</b>

Table 8 (continued). Insulators Strain Index

<b>Calculate the Strain Index (SI) Score:</b> Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
<b>Intensity of Exertion</b> <u>9</u> x	<b>Duration of Exertion</b> <u>3</u> x	<b>Efforts per Minute</b> <u>3</u> x	<b>Hand/ Wrist Posture</b> <u>2</u> x	<b>Speed of Work</b> <u>1</u> x	<b>Duration of Task</b> <u>.75</u>	=	<b><u>SI SCORE</u></b> <u>121.5</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;
- SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

**Table 9. Insulators UE CTD Checklist**

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders (Lifshitz and Armstrong, 1986)*

Date/ Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task Removal of Insulation

\* "No" responses are indicative of conditions associated with the risk of CTD's

<u>Risk Factors</u>	<u>No</u>	<u>Yes</u>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?	N	
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N	
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	N	
6.3 Is the handle of the tool made from material other than metal?	N	
6.4 Is the weight of the tool below 4 kg (9lbs)?		Y
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	18 (82%)	4 (18%)

Table 10. Insulators OWAS

OWAS: *OVAKO Work Analysis System* (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 10/21/99

Area/ Shop: Surface Ship in Drydock

Facility Puget Sound Naval Shipyard

Task: Removal of Insulation

Risk Factor	Work Phase 1	Work Phase 2	Work Phase 3	Work Phase 4	Work Phase 5	Work Phase 6	Work Phase 7
	Using small crow-bar to pop off insulating tie caps overhead (standing on ladder)	Move ladder	Using hawk-bill knife to cut insulation (overhead)	Using small crowbar to pry off insulation	Resting, talking	Pulling insulation off by hand	Spraying down insulation with water
<b>TOTAL Combination Posture Score</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>
<b>Common Posture Combinations (collapsed across work phases)</b>							
Back	2	2	2	1	1		
Arms	3	1	3	1	3		
Legs	1	7	2	1	2		
<b>Posture Repetition (% of working time)</b>	34	11	58	9	2		
<b>BACK % of Working Time SCORE</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>		
<b>ARMS % of Working Time SCORE</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>		
<b>LEGS % of Working Time SCORE</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>		
<b>ACTION CATEGORIES:</b> <b>1 = no corrective measures</b> <b>2 = corrective measures in the near future</b> <b>3 = corrective measures as soon as possible</b> <b>4 = corrective measures immediately</b>							

<b>Risk Factor</b>	<b>Work Phase 1</b>	<b>Work Phase 2</b>	<b>Work Phase 3</b>	<b>Work Phase 4</b>	<b>Work Phase 5</b>	<b>Work Phase 6</b>	<b>Work Phase 7</b>
	Using small crow-bar to pop off insulating tie caps overhead (standing on ladder)	Move ladder	Using hawk-bill knife to cut insulation (overhead)	Using small crowbar to pry off insulation	Resting, talking	Pulling insulation off by hand	Spraying down insulation with water
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	1	2	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	3	1	3	3	1	3	3
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	1	7	2	2	1	2	2
<b>Load/ Use of Force</b>							
1 = weight or force needed is = or <10 kg (<22lbs)	2	1	2	2	1	2	1
2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs)							
3 = weight or force > 20 kg (>44 lbs)							
<b>Phase Repetition</b>							
% of working time (0,10,20,30,40,50,60,70,80,90,100)	34	11	16	17	9	9	2

Table 11. Insulators PLIBEL

*PLIBEL Checklist* (Kemmlert, 1995)Date/ Time: 10/21/99Area/ Shop: Surface Ship in DrydockFacility: Puget Sound Naval ShipyardTask: Removal of Insulation

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
<i>Musculoskeletal Risk Factor Questions</i>	<i>Body Regions</i>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	N				N
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table 11 (continued). Insulators PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	N				N
e) handling beyond forearm length	Y				Y
f) handling below knee length	N				N
g) handling above shoulder height	Y				Y
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table 11 (continued). Insulators PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	16	10	3	3	10
PERCENTAGE	61.5	90.9	37.5	37.5	47.6
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21:Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	Y				
Environmental / Organizational Risk Factors Score					
SUM	4				
PERCENTAGE	40.0				

### A3. Reciprocating Saw Operators

Table 12. Reciprocating Saw Operator RULA  
*Rapid Upper Limb Assessment (RULA)* (Matamney and Corlett, 1993)

Date/Time: 10/21/99

Area/ Shop: Surface Vessel in Drydock

Facility: Puget Sound Naval Shipyard

Task : Cutting of Ductwork with Reciprocating Saw

RULA Component	Frame # 8460 Sawing sheetmetal duct, on floor		Frame # 6720 Sawing sheetmetal duct, on floor		Frame # 15090 Changing saw blade		Frame # 21540 Planning cuts to be made, and methods		Frame # 25050 Re-positioning workpiece	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	sl flex	2	sl flex	2	sl flex	2	sl flex	2	mod flex	3
Shoulder is Raised (+1)		0		0		0		0		0
Upper Arm Abducted (+1)		0		0		0		0		0
Arm supported, leaning (-1)		0		0		-1		-1		0
Elbow Extension/ Flexion	ext	1	neut	2	ext	1	ext	1	ext	1
Shoulder Abduction/ Adduction	add	1	add	1	add	1	neut	0	neut	0
Shoulder Lateral/ Medial	neut	0	neut	0	neut	0	neut	0	med	1
Wrist Extension/ Flexion (left)	ext	2	ext	2	ext	2	neut	1	ext	2
Wrist Deviation	ulnar	1	ulnar	1	ulnar	1	neut	0	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range Or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		1
Arm and Wrist Force/ load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		3		3		1		0		3

Neck Extension/ Flexion		3		3		3		2		2
Neck Twist (+1)		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0
Trunk Extension/ Flexion	sl flex	2	mod flx	3	sl flex	2	sl flex	2	mod flx	3
Trunk Twist (+1)		0		0		0		0		0
Trunk Side Bend (+1)		0		0		0		0		0
Legs If legs and feet are supported and balanced: ( +1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		1
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2
<b>Total RULA Score</b>		<b>7</b>		<b>7</b>		<b>6</b>		<b>4</b>		<b>7</b>
<b>1 or 2 = ACCEPTABLE</b> <b>3 or 4 = INVESTIGATE FURTHER</b> <b>5 or 6 = INVESTIGATE FURTHER AND CHANGE SOON</b> <b>7 = INVESTIGATE AND CHANGE IMMEDIATELY</b>										

Table 13. Reciprocating Saw Operator Strain Index

*STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT*  
(Moore and Garg, 1995)

LOCATION: Puget Sound Naval Shipyard Surface Ship in Drydock, 10/21/99

TASK: Cutting of Ductwork with Reciprocating Saw

1. <b>Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
<i><b>Rating Criterion</b></i>	<i><b>% MS</b></i> (percentage of maximal strength)	<i><b>Borg Scale</b></i> (Compare to Borg Cr-10 Scale)	<i><b>Perceived Effort</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
Somewhat hard	10 - 29%	3	noticeable or definite effort	2	3
<b>Hard</b>	<b>30 - 49%</b>	<b>4 - 5</b>	<b>obvious effort; unchanged facial expression (53% of observed time)</b>	<b>3</b>	<b>6</b>
Very Hard	50 - 79%	6 - 7	substantial effort; changes to facial expression	4	9
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
<b>Intensity of Exertion Multiplier</b>					<b>6</b>

Table 13 (continued). Reciprocating Saw Operator Strain Index

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  % Duration of Exertion  $= 100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$  $= 100 \times \frac{1114 \text{ (sec)}}{1224 \text{ (sec)}}$ $= 91$	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 10	1	0.5
	10 - 29	2	1.0
	30 - 49	3	1.5
	50 - 79	4	2.0
	<b>&gt; or = 80</b>	<b>5</b>	<b>3.0</b>
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  Efforts per Minute  $= \frac{\text{number of exertions}}{\text{Total observation time (min)}}$  $= \text{nearly static exertion, therefore multiplier} = 3$	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 4	1	0.5
	4 - 8	2	1.0
	9 - 14	3	1.5
	15 - 19	4	2.0
	<b>&gt; or = 20</b>	<b>5</b>	<b>3.0</b>
<b>Efforts per Minute Multiplier</b>			<b>3.0</b>

Table 13 (continued). Reciprocating Saw Operator Strain Index

4. <b>Hand/ Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
<b>Rating Criterion</b>	<b>Wrist Extension</b> (Stetson et al, 1991)	<b>Wrist Flexion</b> (Stetson et al, 1991)	<b>Ulnar Deviation</b> (Stetson et al, 1991)	<b>Perceived Posture</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
Fair	26 -40 degrees	16 - 30 degrees	16 - 20 degrees	non-neutral	3	1.5
<b>Bad</b>	<b>41 - 55 degrees</b>	<b>31 - 50 degrees</b>	<b>21 -25 degrees</b>	<b>marked deviation</b> <b>(*estimated, based on RULAs performed)</b>	<b>4</b>	<b>2.0</b>
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/ Wrist Posture Multiplier</b>						<b>2.0</b>

Table 13 (continued). Reciprocating Saw Operator Strain Index

5. <b>Speed of Work:</b> An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
<b>Rating Criterion</b>	<b>Compared to MTM</b> -1 (observed pace is divided by MTM's predicted pace and expressed as % ; See Barnes 1980)	<b>Perceived Speed</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	"taking one's own time"	2	1.0
<b>Fair</b>	<b>91 -100%</b>	<b>"normal" speed of motion</b>	<b>3</b>	<b>1.0</b>
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

6. <b>Duration of Task per Day:</b> Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Duration of Task per Day (hrs)  = duration of task (hrs) + duration of task (hrs) + ....  = (estimate @2-4 hrs; must check w mgmt*** )	< or = 1 hrs	1	0.25
	1 - 2 hrs	2	0.50
	<b>2 - 4 hrs</b>	<b>3</b>	<b>0.75</b>
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
	<b>Duration of Task per Day Multiplier</b>		<b>0.75</b>

Table 13 (continued). Reciprocating Saw Operator Strain Index

<b>Calculate the Strain Index (SI) Score:</b> Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
<b>Intensity of Exertion</b>	<b>Duration of Exertion</b>	<b>Efforts per Minute</b>	<b>Hand/ Wrist Posture</b>	<b>Speed of Work</b>	<b>Duration of Task</b>		<b><u>SI SCORE</u></b>
<u>6</u> x	<u>3</u> x	<u>3</u> x	<u>2</u> x	<u>1</u> x	<u>.75</u>	=	<u>81</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;
- SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table 14. Reciprocating Saw Operator UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders (Lifshitz and Armstrong, 1986)*

Date/ Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task Cutting of Ductwork by Reciprocating Saw

\* "No" responses are indicative of conditions associated with the risk of CTD's

<u>Risk Factors</u>	<u>No</u>	<u>Yes</u>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?	N	
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?		Y
3.6 Can the job be done without "clothes wringing" motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N (Pistol grip)	
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	N (left hand)	
6.3 Is the handle of the tool made from material other than metal?		Y
6.4 Is the weight of the tool below 4 kg (9lbs)?		Y
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	16 (73%)	6 (27%)

Table 15. Reciprocating Saw Operator OWAS

OWAS: *OVAKO Work Analysis System* (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 10/21/99

Facility Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task: Cutting of Ductwork with Reciprocating Saw

Risk Factor	Work Phase 1  Sawing sheet- metal duct, on floor (man 3, team2)	Work Phase 2  Re- position- ing saw	Work Phase 3  Sawing sheet- metal duct, on floor (man 4, team2)	Work Phase 4  Re- position- ing body	Work Phase 5  Transfer saw from person to person	Work Phase 6  Planning cuts to be made, and methods	Work Phase 7  Re- position- ing work- piece	Work Phase 8  Chang- ing saw blade
<b><i>TOTAL Combination Posture Score</i></b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>
<b>Common Posture Combinations (collapsed across work phases)</b>								
Back	2	1						
Arms	1	1						
Legs	6	6						
<b>Posture Repetition (% of working time)</b>	84	13						
<b><i>BACK % of Working Time SCORE</i></b>	<b>3</b>	<b>1</b>						
<b><i>ARMS % of Working Time SCORE</i></b>	<b>1</b>	<b>1</b>						
<b><i>LEGS % of Working Time SCORE</i></b>	<b>3</b>	<b>1</b>						
<b><i>ACTION CATEGORIES:</i></b> <b><i>1 = no corrective measures</i></b> <b><i>2 = corrective measures in the near future</i></b> <b><i>3 = corrective measures as soon as possible</i></b> <b><i>4 = corrective measures immediately</i></b>								

<b>Risk Factor</b>	<b>Work Phase1</b>	<b>Work Phase 2</b>	<b>Work Phase 3</b>	<b>Work Phase 4</b>	<b>Work Phase 5</b>	<b>Work Phase 6</b>	<b>Work Phase 7</b>	<b>Work Phase 8</b>
	Sawing sheet- metal duct, on floor (man 3, team2, kneeling 77% of time))	Re- position- ing saw	Sawing sheet- metal duct, on floor (man 4, team2)	Re- position- ing body	Transfer saw from person to person	Planning cuts to be made, and methods	Re- position- ing work- piece	Chang- ing saw blade
<b>Posture</b>								
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	1	1	2	2
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2, 6	6	6	6	6	6	6	6
<b>Load/ Use of Force</b>								
1 = weight or force needed is = or <10 kg (<22lbs)	2	1	2	2	1	1	3	1
2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs)								
3 = weight or force > 20 kg (>44 lbs)								
<b>Phase Repetition</b>								
% of working time (0,10,20,30,40,50,60,70,80,90,100)	50	4	8	3	1	12	6	13

Table 16. Reciprocating Saw Operator NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
(Waters and Putz-Anderson, 1996)

Date/ Time 10/21/99

Facility Puget Sound Naval Shipyard

Area/ Shop: Surface Shio in Drydock

Task: Cutting of Ductwork with Reciprocating Saw

RISK FACTORS	YES	NO
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?		N
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?		N
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extended kneeling)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?	Y (full body PPE)	
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N
2.2 Does the vertical lifting distance exceed 3 feet?		N
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?	Y (holding sawsall)	
2.5 Do extended reach static holding tasks exceed 1 minute?	Y (holding sawsall)	
<b>TOTAL</b>	6 (43%)	8 (57%)

\* "YES" responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of "YES" responses, the greater the risk.

Table 17. Reciprocating Saw Operator PLIBEL

*PLIBEL Checklist* (Kemmlert, 1995)

Date/ Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task: Cutting Ductwork with Reciprocating Saw

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
<i>Musculoskeletal Risk Factor Questions</i>	<i>Body Regions</i>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			Y	Y	Y
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table 17 (continued). Reciprocating Saw Operator PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table 17 (continued). Reciprocating Saw Operator PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	17	9	2	2	12
PERCENTAGE	65.4	81.8	25.0	25.0	57.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21:Can the work have unusual or expected situations?	Y				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	Y				
Environmental / Organizational Risk Factors Score					
SUM	5				
PERCENTAGE	50.0				

## A4. Tile Chipper

Table 18. Tile Chipper RULA

*Rapid Upper Limb Assessment (RULA) (Matamney and Corlett, 1993)*

Date/Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Vessel in Drydock

Task : Removing Terrazzo Tile from Floor with Chipping Hammer

RULA Component	Frame # 37290 chipping (blade perpendicular to tile)		Frame # 38489 chipping (blade parallel to tile)		Frame # 39960 re-positioning chipper		Frame # 41520 brush away, remove loose tile		Frame # 41520 re-positioning body	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	sl flex	2	sl flex	2	sl flex	2	sl flex	2	sl flex	2
Shoulder is Raised (+1)		1		0		0		0		0
Upper Arm Abducted (+1)		1		0		0		0		0
Arm supported, leaning (-1)		-1		-1		-1		0		0
Elbow Extension/ Flexion	flx	2	ext	1	neut	2	ext	1	ext	1
Shoulder Abduction/ Adduction	mod abd	1	add	1	neut	0	neut	0	neut	0
Shoulder Lateral/ Medial	lat	1	lat	1	neut	0	neut	0	neut	0
Wrist Extension/ Flexion (left)	neut	1	flx	2	ext	2	ext	2	ext	2
Wrist Deviation	ulnar	1	ulnar	1	ulnar	1	neut	0	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range Or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		0
Arm and Wrist Force/ load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		3		3		1		0		0

Neck Extension/ Flexion		3		3		3		3		3
Neck Twist (+1)		1		1		1		1		1
Neck Side-Bent (+1)		0		0		0		0		0
Trunk Extension/ Flexion	mod flx	3	hyp flx	4	mod flx	3	mod flx	3	mod flx	3
Trunk Twist (+1)		0		0		0		0		0
Trunk Side Bend (+1)		0		0		0		0		0
Legs If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		1
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2
<b>Total RULA Score</b>	<b>7</b>		<b>7</b>		<b>7</b>		<b>3</b>		<b>3</b>	
<b>1 or 2 = ACCEPTABLE</b> <b>3 or 4 = INVESTIGATE FURTHER</b> <b>5 or 6 = INVESTIGATE FURTHER AND CHANGE SOON</b> <b>7 = INVESTIGATE AND CHANGE IMMEDIATELY</b>										

Table 19. Tile Chipper Strain Index

*STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT*  
(Moore and Garg, 1995)

LOCATION: Puget Sound Naval Shipyard Surface Ship in Drydock, 10/21/99

TASK: Chipping Terrazzo Tile from Deck with Chipping Hammer

1. <b>Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
<b>Rating Criterion</b>	<b>% MS</b> (percentage of maximal strength)	<b>Borg Scale</b> (Compare to Borg Cr-10 Scale)	<b>Perceived Effort</b>	<b>Rating</b> (circle)	<b>Multiplier</b>
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
Somewhat hard	10 - 29%	3	noticeable or definite effort	2	3
<b>Hard</b>	<b>30 - 49%</b>	<b>4 - 5</b>	<b>obvious effort; unchanged facial expression (66% of observed time hard)</b>	<b>3</b>	<b>6</b>
Very Hard	50 - 79%	6 - 7	substantial effort; changes to facial expression	4	9
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
<b>Intensity of Exertion Multiplier</b>					<b>6</b>

Table 19 (continued). Tile Chipper Strain Index

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  % Duration of Exertion  $= 100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$  $= 100 \times \frac{252 \text{ (sec)}}{278 \text{ (sec)}}$ $= 91$	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 10	1	0.5
	10 - 29	2	1.0
	30 - 49	3	1.5
	50 - 79	4	2.0
	<b>&gt; or = 80</b>	<b>5</b>	<b>3.0</b>
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>  Efforts per Minute  $= \frac{\text{number of exertions}}{\text{Total observation time (min)}}$  $= (58/4.6\text{min}) = 12.5$ , but nearly static exertion, therefore compromise and set <b>multiplier = 2</b>	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< 4	1	0.5
	4 - 8	2	1.0
	9 - 14	3	1.5
	<b>15 - 19</b>	<b>4</b>	<b>2.0</b>
	<b>&gt; or = 20</b>	<b>5</b>	<b>3.0</b>
<b>Efforts per Minute Multiplier</b>			<b>2.0</b>

Table 19 (continued). Tile Chipper Strain Index

4. <b>Hand/ Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
<i><b>Rating Criterion</b></i>	<i><b>Wrist Extension</b></i> (Stetson et al, 1991)	<i><b>Wrist Flexion</b></i> (Stetson et al, 1991)	<i><b>Ulnar Deviation</b></i> (Stetson et al, 1991)	<i><b>Perceived Posture</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
Fair	26 -40 degrees	16 - 30 degrees	16 - 20 degrees	non-neutral	3	1.5
<b>Bad</b>	<b>41 - 55 degrees</b>	<b>31 - 50 degrees</b>	<b>21 -25 degrees</b>	<b>marked deviation</b> (*estimated, based on RULAs performed)	<b>4</b>	<b>2.0</b>
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/ Wrist Posture Multiplier</b> (Fill in)						<b>2.0</b>

Table 19 (continued). Tile Chipper Strain Index

<b>5. Speed of Work:</b> An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
<b>Rating Criterion</b>	<b>Compared to MTM</b> -1 (observed pace is divided by MTM's predicted pace and expressed as % ; See Barnes 1980)	<b>Perceived Speed</b>	<b>Rating (circle)</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	"taking one's own time"	2	1.0
<b>Fair</b>	<b>91 -100%</b>	<b>"normal" speed of motion</b>	<b>3</b>	<b>1.0</b>
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating (circle)</b>	<b>Multiplier</b>
Duration of Task per Day (hrs)  = duration of task (hrs) + duration of task (hrs) + ....  = (estimate @2-4 hrs; must check w mgmt*** )	< or = 1 hrs	1	0.25
	1 - 2 hrs	2	0.50
	<b>2 - 4 hrs</b>	<b>3</b>	<b>0.75</b>
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
	<b>Duration of Task per Day Multiplier</b>		<b>0.75</b>

Table 19 (continued). Tile Chipper Strain Index

<b>Calculate the Strain Index (SI) Score:</b> Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
<b>Intensity of Exertion</b> <b><u>6</u> x</b>	<b>Duration of Exertion</b> <b><u>3</u> x</b>	<b>Efforts per Minute</b> <b><u>2</u> x</b>	<b>Hand/ Wrist Posture</b> <b><u>2</u> x</b>	<b>Speed of Work</b> <b><u>1</u> x</b>	<b>Duration of Task</b> <b><u>.75</u> x</b>	<b>=</b>	<b><u>SI SCORE</u></b> <b><u>54</u></b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;
- SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table 20. Tile Chipper UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders* (Lifshitz and Armstrong, 1986)

Date/ Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task Chipping Terrazzo Tile from Deck with Chipping Hammer

\* "No" responses are indicative of conditions associated with the risk of CTD's

<b>Risk Factors</b>	<b>No</b>	<b>Yes</b>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?	N	
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N	
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?		Y
6.3 Is the handle of the tool made from material other than metal?	N	
6.4 Is the weight of the tool below 4 kg (9lbs)?	N (estimated)	
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	17 (77 %)	5 (23%)

Table 21. Tile Chipper OWAS

OWAS: *OVAKO Work Analysis System* (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 10/21/99

Area/ Shop: Surface Ship in Drydock

Facility Puget Sound Naval Shipyard

Task: Chipping Terrazzo Tile from Deck with Chipping Hammer

Risk Factor	Work Phase 1	Work Phase 2	Work Phase 3	Work Phase 4	Work Phase 5	Work Phase 6
	Chipping (blade perpendicular to tile)	Re- positioning chipper	Chipping (blade parallel to tile)	Re- positioning body	Brush away, remove loose tile	Rest Break
<b>TOTAL Combination Posture Score</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>
<b>Common Posture Combinations (collapsed across work phases)</b>						
Back	2	1				
Arms	1	1				
Legs	6	7				
<b>Posture Repetition (% of working time)</b>	91	9				
<b>BACK % of Working Time SCORE</b>	<b>3</b>	<b>1</b>				
<b>ARMS % of Working Time SCORE</b>	<b>1</b>	<b>1</b>				
<b>LEGS % of Working Time SCORE</b>	<b>3</b>	<b>1</b>				
<b>ACTION CATEGORIES:</b>  <b>1 = no corrective measures</b> <b>2 = corrective measures in the near future</b> <b>3 = corrective measures as soon as possible</b> <b>4 = corrective measures immediately</b>						

<b>Risk Factor</b>	<b><u>Work Phase 1</u></b>  Chipping (blade perpendicu lar to tile)	<b><u>Work Phase 2</u></b>  Re- positioning chipper	<b><u>Work Phase 3</u></b>  Chipping (blade parallel to tile)	<b><u>Work Phase 4</u></b>  Re- positioning body	<b><u>Work Phase 5</u></b>  Brush away, remove loose tile	<b><u>Work Phase 6</u></b>  Rest Break
<b>Posture</b>						
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	2	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	6	6	6	6	6	7
<b>Load/ Use of Force</b>						
1 = weight or force needed is = or <10 kg (<22lbs)	2	2	2	2	1	1
2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs)						
3 = weight or force > 20 kg (>44 lbs)						
<b>Phase Repetition</b>						
% of working time (0,10,20,30,40,50,60,70,80,90,100)	8	11	58	4	10	9

Table 22. Tile Chipper NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
(Waters and Putz-Anderson, 1996)

Date/ Time 10/21/99

Facility Puget Sound Naval Shipyard

Area/ Shop: Surface Shio in Drydock

Task: Chipping Terrazzo Tile Off Deck with Chipping Hammer

RISK FACTORS	YES	NO
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?		N
1.2 Is the object difficult to bring close to the body because of it's size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?		N
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extended kneeling))	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?	Y (outside, vibration)	
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N
2.2 Does the vertical lifting distance exceed 3 feet?		N
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?	Y (holding chipper)	
2.5 Do extended reach static holding tasks exceed 1 minute?	Y (holding chipper)	
<b>TOTAL</b>	6 (43%)	8 (57%)

\* "YES" responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of "YES" responses, the greater the risk.

Table 23. Tile Chipper PLIBEL

*PLIBEL Checklist* (Kemmlert, 1995)Date/ Time: 10/21/99Facility: Puget Sound Naval ShipyardArea/ Shop: Surface Ship in DrydockTask: Chipping Terrazzo Tile from Deck with Chipping Hammer

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
<i>Musculoskeletal Risk Factor Questions</i>	<i>Body Regions</i>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			Y	Y	Y
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table 23 (continued). Tile Chipper PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	N				N
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table 23 (continued). Tile Chipper PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	16	9	2	2	10
PERCENTAGE	61.5	81.8	25.0	25.0	47.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	Y				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	5				
PERCENTAGE	50.0				

## A5. “Cut and Carry” Worker

Table 24. “Cut and Carry” Worker Strain Index

*STRAIN INDEX: DISTAL UPPER EXTREMITY (DUE) DISORDERS RISK ASSESSMENT*  
(Moore and Garg, 1995)

LOCATION: Puget Sound Naval Shipyard Surface Ship in Drydock, 10/21/99

TASK: Carry Material by Hand in Ship Dismantling

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.					
<i><b>Rating Criterion</b></i>	<i><b>% MS</b></i> (percentage of maximal strength)	<i><b>Borg Scale</b></i> (Compare to Borg Cr-10 Scale)	<i><b>Perceived Effort</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1
<b>Somewhat hard</b>	<b>10 - 29%</b>	<b>3</b>	<b>noticeable or definite effort (38% light, 33% somewhat hard, 28% hard)</b>	<b>2</b>	<b>3</b>
Hard	30 - 49%	4 - 5	obvious effort; unchanged facial expression	3	6
Very Hard	50 - 79%	6 - 7	substantial effort; changes to facial expression	4	9
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13
<b>Intensity of Exertion Multiplier</b>					<b>3</b>

Table 24 (continued). “Cut and Carry” Worker Strain Index

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
% Duration of Exertion	< 10	1	0.5
= 100 x $\frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$	10 - 29	2	1.0
= 100 x $\frac{556 \text{ (sec)}}{1162 \text{ (sec)}}$	<b>30 - 49</b>	<b>3</b>	<b>1.5</b>
= 48	50 - 79	4	2.0
	> or = 80	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>1.5</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes. Use the worksheet below and circle the appropriate rating according to the rating criterion, then fill in the corresponding multiplier in the bottom far right box. <b>*NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/ minute multiplier should be set to 3.0</b>			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
Efforts per Minute	< 4	<b>1</b>	<b>0.5</b>
= $\frac{\text{number of exertions}}{\text{Total observation time (min)}}$	4 - 8	2	1.0
= [total # of efforts for observed period, 69/ Total observed time (min) 19.37]	9 - 14	3	1.5
= 3.56	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>0.5</b>

Table 24 (continued). “Cut and Carry” Worker Strain Index

4. <b>Hand/ Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position. Circle the rating after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.						
<i><b>Rating Criterion</b></i>	<i><b>Wrist Extension</b></i> (Stetson et al, 1991)	<i><b>Wrist Flexion</b></i> (Stetson et al, 1991)	<i><b>Ulnar Deviation</b></i> (Stetson et al, 1991)	<i><b>Perceived Posture</b></i>	<i><b>Rating</b></i> (circle)	<i><b>Multiplier</b></i>
Very Good	0 -10 degrees	0 - 5 degrees	0 - 10 degrees	perfectly neutral	1	1.0
Good	11 - 25 degrees	6 - 15 degrees	11 -15 degrees	near neutral	2	1.0
<b>Fair</b>	<b>26 -40 degrees</b>	<b>16 - 30 degrees</b>	<b>16 - 20 degrees</b>	<b>non-neutral (*estimated, no RULA performed)</b>	<b>3</b>	<b>1.5</b>
Bad	41 - 55 degrees	31 - 50 degrees	21 -25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/ Wrist Posture Multiplier</b> (Fill in)						<b>1.5</b>

Table 24 (continued). “Cut and Carry” Worker Strain Index

5. <b>Speed of Work:</b> An estimate of how fast the worker is working. Circle the rating on the far right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.				
<b>Rating Criterion</b>	<b>Compared to MTM</b> -1 (observed pace is divided by MTM's predicted pace and expressed as % ; See Barnes 1980)	<b>Perceived Speed</b>	<b>Rating (circle)</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81 - 90%	“taking one’s own time”	2	1.0
<b>Fair</b>	<b>91 -100%</b>	<b>“normal” speed of motion</b>	<b>3</b>	<b>1.0</b>
Fast	101-115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed and barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

6. <b>Duration of Task per Day:</b> Either measured or obtained from plant personnel. Circle the rating on the right after using the guidelines below, then fill in the corresponding multiplier in the bottom far right box.			
<b>Worksheet:</b>	<b>Rating Criterion</b>	<b>Rating (circle)</b>	<b>Multiplier</b>
Duration of Task per Day (hrs)  = duration of task (hrs) + duration of task (hrs) + ....  = (estimate @4 hrs; must check w mgmt*** )	< or = 1 hrs	1	0.25
	1 - 2 hrs	2	0.50
	<b>2 - 4 hrs</b>	<b>3</b>	<b>0.75</b>
	4 - 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
	<b>Duration of Task per Day Multiplier</b>		<b>0.75</b>

Table 24 (continued). “Cut and Carry” Worker Strain Index

<b>Calculate the Strain Index (SI) Score:</b> Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
<b>Intensity of Exertion</b> <b><u>3</u> x</b>	<b>Duration of Exertion</b> <b><u>1.5</u> x</b>	<b>Efforts per Minute</b> <b><u>0.5</u> x</b>	<b>Hand/ Wrist Posture</b> <b><u>1.5</u> x</b>	<b>Speed of Work</b> <b><u>1</u> x</b>	<b>Duration of Task</b> <b><u>.75</u></b>	<b>=</b>	<b><u>SI SCORE</u></b> <b><u>2.5</u></b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5-30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31-60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE;
- SI Score > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table 25. “Cut and Carry” Worker UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders* (Lifshitz and Armstrong, 1986)

Date/ Time: 10/21/99

Facility: Puget Sound Naval Shipyard

Area/ Shop: Surface Ship in Drydock

Task Carrying Material by Hand in Ship Dismantling

\* “No” responses are indicative of conditions associated with the risk of CTD’s

<b>Risk Factors</b>	<b>No</b>	<b>Yes</b>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N/A	N/A
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N/A	N/A
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N/A	N/A
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	N/A	N/A
6.3 Is the handle of the tool made from material other than metal?	N/A	N/A
6.4 Is the weight of the tool below 4 kg (9lbs)?	N/A	N/A
6.5 Is the tool suspended?	N/A	N/A
<b>TOTAL</b>	9 (60%)	6 (40%)

Table 26. "Cut and Carry" Worker OWAS

OWAS: *OVAKO Work Analysis System* (Louhevaara and Suurnäkki, 1992)

Procedure: Observe workers at intervals of 30-60 seconds and record the postures and forces over a representative period (~ 45 minutes)

Date/ Time 10/21/99

Area/ Shop: Surface Ship in Drydock

Facility Puget Sound Naval Shipyard

Task: Carrying Material by Hand in Ship Dismantling

	Work Phase 1: Tandem carrying material to bin	Work Phase 2 Single carrying material to bin	Work Phase 3 Bin arranging	Work Phase 4 Brigade carrying material to bin	Work Phase 5 Lifting material off pile	Work Phase 6 Walking back and forth	Work Phase 7 Waiting for crane, resting
<b><i>TOTAL Combination Posture Score</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>2</i></b>	<b><i>1</i></b>	<b><i>2</i></b>	<b><i>1</i></b>	<b><i>1</i></b>
<b>Common Posture Combinations (collapsed across work phases)</b>							
Back	1	2	4	1			
Arms	1	1	1	1			
Legs	7	2	2	2			
<b>Posture Repetition (% of working time)</b>	22	7	23	18			
<b><i>BACK % of Working Time SCORE</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>2</i></b>	<b><i>1</i></b>			
<b><i>ARMS % of Working Time SCORE</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>			
<b><i>LEGS % of Working Time SCORE</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>	<b><i>1</i></b>			
<b><i>ACTION CATEGORIES:</i></b>  <b><i>1 = no corrective measures</i></b> <b><i>2 = corrective measures in the near future</i></b> <b><i>3 = corrective measures as soon as possible</i></b> <b><i>4 = corrective measures immediately</i></b>							

<b>Risk Factor</b>	<b>Work Phase 1: Tandem carrying material to bin</b>	<b>Work Phase 2 Single carrying material to bin</b>	<b>Work Phase 3 Bin arranging</b>	<b>Work Phase 4 Brigade carrying material to bin</b>	<b>Work Phase 5 Lifting material off pile</b>	<b>Work Phase 6 Walking back and forth</b>	<b>Work Phase 7 Waiting for crane, resting</b>
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	1	1	2	1	4	1	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	7	7	2	7	2,7	7	2
<b>Load/ Use of Force</b>							
1 = weight or force needed is = or <10 kg 2 = weight or force > 10 but < 20kg 3 = weight or force > 20 kg	2	2	2	2	2,3	1	1
<b>Phase Repetition</b>							
% of working time (0,10,20,30,40,50,60,70,80,90,100)	10	2	7	5	23	5	18

Table 27. “Cut and Carry” Worker NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
(Waters and Putz-Anderson, 1996)

Date/ Time 10/21/99

Facility Puget Sound Naval Shipyard

Area/ Shop: Surface Shio in Drydock

Task: Carrying Material by Hand in Ship Dismantling

RISK FACTORS	YES	NO
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?		N (usually not)
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Y	
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y ( lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?		N (cold, heat occasionally)
1.9 Does the task require working in a confined area?	Y	
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 3.4 over total cycle time)
2.2 Does the vertical lifting distance exceed 3 feet?		N
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?		N (usually @ 5-10)
2.5 Do extended reach static holding tasks exceed 1 minute?		N
<b>TOTAL</b>	5 (36%)	9 (64%)

\* “YES” responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of “YES” responses, the greater the risk.

Table 28. “Cut and Carry” Worker 3D Static Strength Prediction Program

*3D Static Strength Prediction Program* (University of Michigan, 1997)

*Date/ Time:* 10/21/99

*Facility:* Puget Sound Naval Shipyard

*Area/ Shop:* Surface Vessel in Drydock for Dismantling

*Task:* Carrying Material by Hand

<b>Work Element:</b>	<b>Disc Compression (lbs) @ L5/S1</b> (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs.)
Lifting a 40 pound item out of a scrap bin, two-handed	741.4 lbs.
Pulling a 40 pound item out of a scrap pile, two-handed	501.0 lbs.
Lifting a 20 pound item off a scrap pile, one-handed	549.7 lbs.
Tandem lift of 40 pound item (20 pounds per person), each two-handed	311.8 lbs.

Table 29. “Cut and Carry” Worker PLIBEL

*PLIBEL Checklist* (Kemmlert, 1995)Date/ Time: 10/21/99Facility: Puget Sound Naval ShipyardArea/ Shop: Surface Vessel in Drydock for DismantlingTask: Carrying Material by Hand

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
<i>Musculoskeletal Risk Factor Questions</i>	<i>Body Regions</i>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	N				N
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	N				N

Table 29 (continued). “Cut and Carry” Worker PLIBEL

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	Y				Y
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	N	N			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table 29 (continued). “Cut and Carry” Worker PLIBEL

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	16	7	4	4	14
PERCENTAGE	61.5	63.6	50	50	66.7
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
Answer below questions, use to modify interpretation of musculoskeletal scores					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	4				
PERCENTAGE	40.0				